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LOVINGLY

TO MY WIFE AND CHILDREN

PREFACE

This essay appeared as a series of articles in the *Yorkshire Observer* during October of this year. It was called forth by the discussion of the origin of life revived by Dr E. A. Schäfer's presidential address at the recent meeting of the British Association. It is not in any sense a "reply" either to the address itself or to any of the speeches that followed it. My object has not been to take sides, but to demonstrate the barrenness of the ground on which this discussion has been and still is being carried on.

From the scientific standpoint there is nothing to choose between the materialistic theory of life (or of the universe) and the one to which it is opposed. Each is building on "fundamental as-

sumptions."[1] The one assumes a supreme self-conscious "spirit" or "will," and the other a self-potent "matter" or "substance." The one is as untenable as the other.

The idea that is lurking behind this materialistic philosophy is the old metaphysical conception of matter as *something* that is *endowed* with "properties" and in which the "forces" (or "spirits" in Lord Bacon's picturesque language) were *indwelling*. It is these obsolete conceptions of matter—deep-rooted as they are in thought and speech—which, unconsciously, influence the mind of even those who would repudiate these ideas were they formally posited as postulates of a possible philosophy.

In the light of modern science matter can no longer be regarded as something apart from, or in addition to, its manifestations. Matter itself is a manifesta-

[1] I borrow this phrase from Dr A. Weissmann's *Germ Plasm*, a book which is a glaring example of this kind of pseudo-science.

tion of that unknown something which seems to be behind every phenomenon; and the theory which will explain matter will also explain life. "Life" and "matter" do not stand to each other in the relation of cause and effect. Neither is the product of the other. This much may be affirmed with certainty. The problem concerning both may be stated in these identical words: What is the cause of these manifestations?

To show where and in what manner an answer might be found to this question was the object of this essay. Science, so far, has triumphed chiefly in the laboratory where the *student* has followed the method which proceeds from the known to the unknown, using well-established facts as stepping-stones. It has failed in the study where the *philosopher*—forgetful how the student got his successes—sallies forth with an assumption in the hope of arriving at a fact. But this is no longer science, though unfortunately regarded as such

merely because philosopher and student happen to be one and the same person.

If scientific men speculating in the study would only adhere to the same rules of reasoning they perforce must follow when in the laboratory, their successes in the domain of philosophy would soon equal those fought out in the workroom, and answers might be found to many apparent mysteries, even though we should never be able to explain the absolute. Such questions, for instance, as a first cause must ever remain without an answer, because unanswerable. We need only paraphrase "first cause" into "origin of origins" to see the absurdity of the quest.

I. S.

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I

There are some points in connection with this problem which—from a layman's point of view—seem to have been overlooked by the biologists at the Dundee meeting of the British Association.

The first assertion that calls for comment is the conclusion of the defenders of the materialistic theory that "the final word must be spoken by the chemist." I beg to doubt this. Indeed, I will go further and prove the statement to be wrong. The assumption is that if you had "protoplasm" or "cytoplasm" or "chromatin," you would have "life" or "living matter."

Nothing is easier than to supply these

substances. I do not mean that they could be produced synthetically—for I do not believe we could tell whether the substance was the right one after it had been made, for reasons that shall presently appear—but merely that we can obtain any such product ready-made from nature. Say, for instance, the white of an egg, or the whole egg; the juice of a plant, or the seeds of a plant, crushed; or a whole plant, or animal, pounded up.

In any of these there would be present the substances in just the right combinations to produce all the phenomena of life. I do not propose to ask these biologists to produce anything "living" out of these substances. I am aware of all the practical difficulties which beset the subject of experimentation and interpretation. What I do desire to know is how they would proceed to demonstrate that, a certain chemical compound given—whatever its composition—they could produce from it what is called "life."

Let me explain the difficulties I am thinking of. The egg, if hatched in the ordinary way, would produce a particular bird, of a particular structure and colour, possessing certain habits of life, etc. All these peculiarities are the result of former conditions and habits of life, accumulated through countless generations, and have nothing whatever to do with the atoms of matter or their chemistry. They are the reproductions of a long series of habits and adaptations.

It seems obvious to me that the substance just prepared in the chemist's flask could possess no such prior "habits," or acquired dispositions, and therefore could not respond to any stimuli. Or is there anything in what we call "life" that is not a reproduction of an acquired "habit"—whether of shape, structure, or function—even to the simplest response to external stimuli? If there is, then it should be present in the fresh and fertile egg, even after yolk and white have been pounded up. For it is not conceiv-

able that by pounding any of the chemical properties have been changed.

What has been destroyed by the pounding up is the power of reproducing the peculiarities of countless generations of birds stored up in the minute speck of the germ; but none of its chemical properties. The substance is still as it was a minute ago—"living matter."

Or not? And why not? It is inconceivable that the chemist should be able to make a compound that should be more "living matter" than this perfectly fresh albumen just taken from the shell of a new-laid and fertile egg. How can we demonstrate that there is life in it, or that there is not?

Before either question can be answered, we should be able to state what we regard as "life." Until this is done, until we know what precisely is meant by the term "life," it seems idle to discuss whether we can produce it artificially or not.

"Give me protoplasm and I will give

you 'life,'" says the materialist. I believe I have said enough to show how mistaken the assertion is. The chemist could produce nothing more "living" than the contents of an egg. But how is he to tell it is "living," even when he has it?

It is different, however, when the evolutionist says, "Give me an amœba and I will show you how it may grow into a man." True, he cannot make an amœba into a man, or even into a much simpler organism, in the time at his disposal. But he can prove, nevertheless, how the most complex organisms have evolved from the simplest forms of "life," and that experimentally, be it understood, and in the same way as we can prove that the centuries-old oak has sprung from an acorn.

The experiments we require for our demonstration have providentially been prepared for us by nature. We find the acorn as it dropped from the tree, another just showing signs of sprouting; yet

another having pushed out its cotyledons and radicle; and so on, through seedlings at different ages and stages of development up to the full-grown seed-bearing oak.

In like manner do we not only possess "living" creatures from the amœba to man in all stages of development, but we can often witness the formation of new characteristics and the passing on of these to offspring, until — conditions being favourable—these newly acquired habits become in time established characteristics, and possibly even essential conditions of existence. We can see "life" in the making.

I do not deem it necessary to enlarge on this phase of my argument. Evolution from simpler forms is not only admitted by all who have paid any attention to the subject; it is used systematically by breeders and botanists to improve breeds and to produce new varieties.

Let us inquire, then, what is the

principle underlying this process of evolution. If we could trace the history of "life" from a simple cell to an oak, or to man, then it should not be impossible, by tracing backwards the same process, to find the origin of the cell itself.

II

I will not trouble about the laboratory experiments that have been made to prove or to disprove "spontaneous generation," nor about the arguments that have been urged for or against the conclusions the various experimentalists have arrived at. It is established beyond doubt that when properly sterilised and protected against the possibility of larvæ, spores, seeds, etc., getting into the substance, organic matter of any kind may be preserved indefinitely without showing signs of life. The enormous mass of foodstuffs preserved in this way is an experiment on the grandest scale to prove this.

I am also aware of the counter arguments, but will not trouble to consider them, because I hope that the explanation I intend to offer in these pages will make this superfluous. But the fact that the very opponents of biogenesis are looking to the chemist to solve the mystery of "life" makes it worth while to point out that all the objections they themselves are urging with such forceful effect against the experiments and arguments of the defenders of biogenesis would—*a fortiori*—also tell against the synthetic product. For the whole argument against spontaneous generation may be summed up as follows: With proper sterilisation and isolation no life has yet been produced, and where life has resulted this in itself was evidence of insufficient sterilisation or improper isolation.

To meet these objections the synthetic albumen would not merely have to possess all the potentialities of life, but would have to be able to produce it under con-

ditions under which no natural proteid substance is capable of doing so.

On reflection, the whole problem under discussion will be seen to be falsely conceived and wrongly stated. What, for instance, is intended to be proved by such experiments to produce "living" from "non-living" matter? The identity of matter in living and non-living; or, that matter is "life"? If the former, a positive affirmative answer may be given on most conclusive evidence. If the latter, an equally emphatic negative answer is possible. In other words, "life" cannot be explained or accounted for in terms of matter. I will show this to be the case by answering the above two questions.

First, then, as to the identity of matter in living organisms and in unorganised or non-living bodies. (The reader will notice that I am endeavouring to avoid such phrases as "living" and "dead" matter. There is no "dead" matter, if by that is meant inertness.) This identity

may be and has been proved already without the necessity of producing an amœba. There can be no question that the carbon, hydrogen, nitrogen, oxygen, and other atoms in the bodies of living beings are the same as in inorganic bodies. We may establish this in two ways: by direct analysis of tissues from living bodies, and by the feeding of plants and animals. We have reached a stage at which we can feed a plant entirely on matter derived from inorganic bodies, *i.e.* water, carbon dioxide, nitrogenous and phosphatic manures. With such plants we may feed herbivorous animals, and with the latter the carnivora, and also man.

This and analysis sufficiently establish identity of matter in living and non-living bodies; but that does not explain the mystery of life, nor prove matter to be the cause of it. True, life is never observed apart from matter. Neither is heat, electricity, gravitation, or magnetism. But that does not establish

identity. We may abstract the heat of a body and transfer it to another without altering shape or mass of that body. We may do so through space. We may burn coal in England, convert the heat into electric current, and send it across the Atlantic to America to reappear there as heat, light, or electricity. We may measure the quantity of that heat; change it into other forms of energy, always in connection with matter only; yet we cannot identify it with the matter, nor account for it by the latter. Indeed, it would be much easier to account for matter in terms of energy than for energy in terms of matter. So, likewise, as I hope to be able to show, it is easier to account for the organism by life than for life by organisation.

This brings me to the second question: Is matter life, or does matter in any way account for life?

The experiments necessary to answer this question need not be made in the laboratory. Nature has made them for

us, and we are all of us so familiar with them that it is not at all surprising the savants at Dundee should have failed to take note of them.

We place a seed in the ground, say a cherry stone. That seed will germinate, take from the soil and the air carbon, hydrogen, nitrogen, oxygen, potassium, phosphorus, etc., and will build up a tree. Not *any kind* of a tree, but a cherry-tree, producing not *any kind* but a *particular kind* of a cherry (for the purpose of this argument we may ignore the tendency to reversion by propagation from seeds) black or red, sweet or sour, having a long and thin or short and thick stalk, as the case may be, reproducing the parent type. We explain this reproduction by calling it heredity. But what has this tree inherited from the parent tree? The carbon, hydrogen, oxygen, nitrogen, etc.? Surely not. Or the compounds? It had to make them out of the elements. There may not be a single atom in the tree that came from

the parent stock. Equally evident is it that it is not the organising power of the atoms of matter that has built up the tree, but rather the *germ* that has organised the atoms into just such combinations as, from the parent, it had learnt to produce.

Had we sown instead an acorn, a hevea, or a eucalyptus seed, the same carbon, hydrogen, and other atoms might have been organised into an oak, a rubber, or a eucalyptus tree. Instead of cherries we should have had, from the same raw materials, acorns, rubber, or eucalyptus seeds, and, incidentally, in place of the acid of the cherries, tannin, caoutchouc, or an essential oil.

Clearly it is not, then, the combinations of the atoms of matter that account for the tree, or the life of the tree; but the latter which accounts for the former.

We may take man for our next example. A child may be brought up from birth on food with which the mother had no concern. The child may

never have seen the parents. Yet, unconsciously, it builds up out of the carbon, hydrogen, oxygen, etc., it derives from wheat, cow's milk, the air, a body resembling that of the parents in size, shape, and colour, reproducing dispositions, habits, temperament, etc., even to such comparative trivialities as the habit of blushing, as gestures, likes and dislikes. We are in the habit of saying that "the blood of his sires is coursing in the veins" of so and so. As a matter of fact, none of us have a single atom of matter of our sires in our composition, much less a single drop of their blood. Or, if we have, the atoms have come to us so transformed that it no longer matters whether they belonged to any of our ancestors or not.

We do not inherit our bodies, but only the "skill" to build them up (out of heterogeneous atoms, gathered from here and there in the form of grain, fruit, meat, etc.) after a pattern supplied to us by our sires in a mysterious manner

without consciousness on their part or our own.

We have inherited the "genius" of our sires to arrange the atoms in certain combinations and forms; but not the atoms themselves. And as it is this *genius* that makes these combinations, it cannot be the combinations that make the organism.

Besides, organised matter shows no more signs of life than unorganised, if that "genius"—whatever we may call it—be absent. Let us take, for instance, a bird, place it into a closed box and withdraw the oxygen. We may thus asphyxiate the bird without altering the chemistry or the organisation of the *body*. But "life" would be extinct.

We should still be in possession of the *organised body* of the bird, but no longer of the *genius* that built it up. The chemical compounds are still there, and the organisation is there all unimpaired. What need to trouble the chemist to make any of the constituent substances,

when they are so conveniently obtainable? What is wanted is not a chemist who can make any or all of the compounds in the body of that bird, but the genius—chemist and architect at the same time—which built up that body.

In other words, it is not the chemical compounds that have made the oak, the rubber, or the cherry tree, but the "tree" that made the compounds; and by "tree" I do not mean here the finished, visible, and materialised thing, so much as the immaterial, invisible, and mysterious *power* which built it up after a definite plan, converting practically the same carbon, hydrogen, oxygen, etc., in the one case into tannin and in the others into caoutchouc, oil, starch, sugar, etc. To explain the mysteries of life, therefore, it is not so much the chemist that is needed, who can make any or all these substances, as the power that can make the chemist. For it is that power which made the chemical compounds, and not *vice versa*.

To put it colloquially, the problem with which we are faced is not how the chemist might make protoplasm, so much as how the protoplasm is able to make the chemist.

III

The material available for the study of life is immense. Not only have we, each of us, our own experiences of self and those around us, but a mass of clinical and experimental evidence has been accumulated which is stupendous both in quantity and completeness of range. But, unfortunately, it is not among these that philosophers are trying to find an explanation of the mystery of life. Consciously or unconsciously, their quest has followed along old-established paths, and is pursued by discarded and discredited methods. Whatever form the inquiry may assume, there is always lurking in it the spirit of controversy rather than that of scientific investigation. "Soul or body"?

"Spirit or matter"? These seem to be still the questions underlaying the problem, and the inquiry seems to be conducted within the narrow limits of these antiquated channels, while the teeming mass of accumulated facts bearing on the problem are left outside unheeded. But so soon as the man of science quits the firm ground of facts and enters the misty realms of speculation, he is as much at the mercy and the sport of the imagination as is the man who, riding on a cloud of assumption, hopes by means of a syllogism to alight upon a fact. Such reasoning, it should not be forgotten, is no longer science; and, though performed by an otherwise competent student of science, conclusions thus reached have no greater value than any others arrived at by similar methods.

It is pure assumption that "matter," as commonly understood, explains anything or accounts for anything. Matter does not account for gravitation, heat,

electricity, light, or for its own existence. The whole conception of matter has changed within the last few decades in the minds of those who have paid attention to recent progress in physical science. Michael Faraday was the first, I believe, to assert that "it is the force that constitutes the matter"; and this view is steadily gaining ground. But to abandon the no longer tenable materialistic standpoint does not mean acknowledging the view to which it was opposed as being the correct one. It is a third error to suppose that one or other of two opposing theories is bound to be correct. We may disregard both, and instead of arguing in the abstract for or against either, let us turn to the abundant facts of life and see what they can teach us about life itself.

As I have said already, the available material for the study of life is immense. There is no need for any artificial experiment. Whatever phase of life we may desire to study, the

necessary information is at hand and in profusion. The difficulty is one of space and time rather than of selection. The necessary limits of this essay will not allow me to enter so fully into the evidence as the importance of the subject would demand and the facts would enable me to do. Nor is it so much my object to explain fully and satisfactorily the mysteries of life as to indicate how this might be done. It is to point the way rather than to accomplish the task myself that I desire.

Let us note, then, some facts to start with. We have seen how the parent type is reproduced by the offspring, and how the latter builds up an organisation from materials *prepared by itself* out of bodies which contain the requisite elements. We have also noted that though the ultimate atoms are the same, or practically the same, the proximate substances vary from which different plants are built up. We find among plant constituents such differing bodies

as acids, alkaloids, oils, waxes, gums, resins, starches, sugars, caoutchouc, etc., all prepared by the plants themselves out of bodies that do not contain them. Similar variations of constituents, though not to the same extent, are to be found in animals. These, too, make the products from which their bodies are built up. But there is this difference, that whereas plants are capable of drawing the material needed from the inorganic kingdom, animals are chiefly dependent for their food on the organic kingdom. They can assimilate—with but very few exceptions—vegetable or animal food only.

Here, again, is a marked difference between the herbivorous and carnivorous animals. Other animals, men included, can live on either vegetables or flesh, thus showing that — although a lion would starve if it had nothing but dates and rice to feed on, and that an elephant would starve on beef and mutton—either kind of food is capable of supporting life,

and that the exclusive diet of the herbivora and the carnivora is more a matter of habit than of constitution. It is also well to notice that by long-continued use an animal may, from being omnivorous, become either vegetarian or meat-eater, and that such *acquired habit* may be transmitted to offspring.

The transmission of a habit acquired during the life of the individual does not necessarily follow in every case. But if through circumstances the offspring should be forced to continue the habit, and this should be the case for several generations, such habit may become established, and may even become a condition of existence. Many well-known facts could be cited in illustration if space permitted. I will only mention the creation of new varieties of plants and animals by crossing and *their fixation.* This, as is well known, is done by selection, and the new variety is the more permanent the longer its existence. Thus a variety that has bred true for,

say, twenty generations can be more depended on to breed true than one just created.

I must perforce leave it to the reader to supply additional evidence of the acquisition of new habits owing to changed conditions of life—the general decay of the teeth, the tendency to short-sightedness among students using the microscope, and the narrow jaws of American offspring from Europeans are examples—and their transmission. The law as to this may be thus formulated: The older a habit, the greater its tendency to persist and to be transmitted, till, in time, it may become a necessary condition of existence. The rule applies, of course, to plants as well as to animals, and where any difference is observable, it can always be shown to be one of degree only.

IV

I propose to show now that these habits are local; *i.e.* that the different

organs or members of a complex body have a psychic life of their own, and that this is the case even when such member cannot continue to live for long after having been severed from the rest. Subdivision and propagation by cuttings in plants are familiar enough. In the animal kingdom this is possible in the lower and lowest forms of life only, where specialisation of the cell has not yet been carried too far.

A polyp, for instance, or any of the jelly-like creatures, in which any part of the body can feed itself, may be subdivided to almost any extent, and each part will continue a separate existence. In the higher organisms such subdivision causes death, in the amputated member at least, if not in the main body itself, because such part is no longer able to forage for itself. But where it can be contrived to continue the feeding by some means or other, the life of any such amputated member of an animal may be continued, and such member would

respond to local stimuli as before, showing that though its existence depended on the co-operation of the remaining co-ordinated parts of the body, the life and habits were nevertheless its own. An amputated leg, for instance, possesses all the powers of life and sensation it possessed before. It depended on the main body for its sustenance only. The powers of sensation and response to stimuli were entirely its own, however, even when still with the body, as we shall presently see.

This continuation of "life after death" —if I may be permitted to use the paradox—is readily observable in the lower organisms, and the more so the lower down we descend in the scale, but is really most powerful in the higher animals — strongest in man himself — though not observable unless specially evoked. The legs of a spider afford familiar illustrations. After having been severed from the insect they are seemingly dead; but if touched they

will convulse and kick as if anxious to run away, but, of course, cannot do so for physical reasons. In the legs of man, such "reflex actions," as they are wrongly called, are stronger still, as will shortly appear. The hearts of cold-blooded animals will continue to throb for several hours after having been removed from the body, and the animal itself, say a fish, will wriggle with great force after its removal. The eyes of a frog may be removed and kept in a darkened box for several hours and will respond to the stimulus of light.

Many other instances might be cited showing the independent vitality of the different organs and members of the more complex animals, and on this fact is based the theory of cellular psychology. Briefly stated, it means that every cell, whether existing separately and independently — unicellular — or whether forming part of a complex body, has a psychic life of its own, the only difference being that whereas the cells of the

simple organisms are independent of each other, those welded into a more complex organism are specialised for the performance of certain functions, and consequently are dependent for their existence on each other.

I will return to the subject of specialisation and co-ordination further on. For the present I desire to confine my remarks to showing that the reason why a severed member of any of the higher animals cannot continue to live is chiefly because it is no longer able to forage for itself. In the case of an internal organ, such as the heart or kidney, there would also be the conditions of existence to be considered. But there is every reason to believe that, if the missing conditions could be supplied artificially, any part of an animal could continue to live, even after being severed from the rest. This conclusion has now been amply verified experimentally, and some marvellous surgical operations have been

successfully performed by the aid of this knowledge.

I will instance one or two such experiments that have actually been made. The end of the tail of a rat was bared and inserted under the skin of the back of the animal, and was firmly kept there until the wound had healed. The end of the tail thus inserted grew on to the back of the rat. The other end was severed so that the tail grew now on the back of the rat instead of at its former place and in a reversed position, but the tail was alive like any other part of the body, could be bled or wounded, and such wound would heal again; but the rat had no longer any control over the movements of its tail. The leg of a young rat was grafted to the side of an old rat. The leg grew as it should have done, although it was not of the slightest use to its new owner.

Taking skin from one person to cover the flesh of another person where the skin had been destroyed by some accident

is now not an uncommon operation. But what is of interest in the matter under consideration is that any such member or tissue grafted on to another individual retains its own characteristics, and does not partake of the nature of the individual it is grafted on to; it merely feeds on it. Thus, if a piece of skin of the upper lip of a man were grafted on the face or arm of a lady, it would continue to produce hair as if it had remained where it was and grown a moustache. The similarity of this operation with the practice of grafting trees with buds from another tree will readily occur to the reader.

There are any number of pathological cases fully reported that can be made to throw a flood of light on the subject under consideration, and it is surprising that philosophers who are interested in the broader problems of life find such little use for this material. I will quote one case only, a case of paraplegia—or "palsy," as it is commonly called—re-

ported by Dr Hunter and quoted by Dr Carpenter in his *Human Physiology*. In this case, paraplegia was the result of angular distortion of the spine in the dorsal region. The power of voluntary motion of the lower extremities was entirely lost. When, however, any part of the skin was pinched or pricked, the limb thus acted on jumped "with great vivacity." When the patient was asked whether he felt the irritation by which the motions were excited, he significantly replied, glancing at his limbs: "No, sir; but you see my legs do." The report is too long for quotation *in extenso*, though full of interest. When the instep was tickled with a feather, we are told, violent convulsions resulted in the form of a rapid succession of jerks and kicks. In another similar case, hot plates were strapped to the soles. The legs—over which the patient had no control at all, and which, except when locally excited, were to all appearances lifeless—began to walk rapidly as if trying to get off

the hot plates, until the wall made further progress impossible. But the legs kept on "walking," and the patient had no power to stop them.

Such motions, because not volitional, are called—quite wrongly, as I believe —"reflex" actions. If a person happens to step on to a hot plate with bare feet he naturally hurries off it, and the person thus acting takes credit to himself for the act. As a matter of fact, the legs can do so for themselves, and, in certain circumstances, do act thus independently, the mind merely being conscious, during or after the event, of what has taken place. I shall not pursue the subject any further than to point out the only conclusion I desire to draw at present from these facts, and that is that organs, down to the individual cells in these organs, have a life of their own, and are dependent for their existence on the remaining part of the complete organisation, because they have become specialised to a degree that no longer

enables them to forage for themselves or to exist apart.

But for this circumstance, any part of an animal would be capable of continuing its existence apart from the body and of performing its functions, even though no reason existed any more for doing so. We are too accustomed to look upon a complex organism, such as man, for instance, as an "individual," whereas in reality he is an empire of cells, each trained to perform certain functions, the whole constituting a wonderful organisation.

V

Let us now take another step. Having arrived at the conclusion that the complex body consists of a mass of highly specialised cells, subordinated and coordinated to one another, let us see whether we could trace this process of specialisation.

A peculiar and a *fundamental pro-*

perty of the cell—or is it that of the substance of the cell ?—is its adaptability and persistence. I will explain what I mean by these terms. By "adaptability" I mean adaptability to conditions; and by "persistence" the tendency to continue under any given conditions, or to resist change. These two peculiarities, we shall find, are the chief factors of organic life even as to origin, modification, propagation, heredity, etc.

For illustrations of either principle we need not go outside personal experience. To cite but a few familiar facts: We may get "tired" of sitting as of walking, but we do not feel this "tiredness" until we desire to change from rest to motion or from motion to rest. After sitting for many hours in one posture, it hurts us to get up and walk. So, likewise, after having walked for a longer period than usual, we get "tired" certainly; but the pain will not be felt till we sit down. Indeed, the necessity of taking a rest is because of exhaustion

rather than of "tiredness"; for the muscles would work the more easily the longer they kept on doing the *same* work. The intermittent rest is necessary for those muscles only that are not habituated to constant work.

The heart and lungs are illustrations in point. The former especially performs a fairly heavy task, pumping the blood with a considerable force through the system without ever "resting," and gets "tired" or painful only when disturbed in the regular performance of its work. The illustrations that might be given are co-extensive with life itself; but I must content myself with the bare statement of the "law" and a few familiar instances of its operation by way of illustration.

It is the tendency *to persist* which is responsible for most—if not, indeed, all—the phenomena of life, and which accounts for the diversity of conditions of existence. The same cell, or group of cells, may exist in air or in water, in

cold or warm climates (within certain limits of course), and under the most diverse conditions; and such conditions would in time become essentials of existence; the *more essential the longer the "habit" had been established.*

The conditions of life are by no means so limited as is generally supposed, if we include all forms of living bodies—*i.e.* organised bodies, that can respond to stimuli, feed, and propagate. As Darwin expressed it as early as on his voyage in *The Beagle*: "Well may we affirm that every part of the world is habitable. Whether lakes of brine, or those subterranean ones hidden beneath volcanic mountains—warm mineral springs—the wide expanse and depth of the ocean—the upper regions of the atmosphere, and even the surface of perpetual snow—all support organic beings."

Not only can organic beings exist under *any conditions* that do not make the existence of the organic compound itself impossible—as excessive heat or

cold—but they can adapt themselves to the most varied conditions, *provided only that the changes are not too sudden*, and the "habit" to be modified not too long established. It is the suddenness of the change that so often proves fatal, and not any inherent impossibility of living under the changed conditions. Thus, an aquatic animal or plant would perish on land, and a land animal or plant in water; not because either air or water is incapable of supporting life, but because the respective beings have adapted themselves to one or other of these "elements" and are unable to change suddenly from one set of conditions to the other.[1] The axolotl, for

[1] "That portion of the earth has yet to be found which could not be inhabited or at least visited by some race or other. It is true, the transitions from different climates must not be too sudden. Even Icelanders who emigrate to Copenhagen are apt to perish from consumption, although they are of common origin with the Danes, and only eight hundred years ago spoke the same language."—Oscar Peschel, *The Races of Man.*

instance, lives in water, but later in life becomes a land animal.

With the higher animals—and plants, too—any sudden changes may prove fatal. A mere change of climate or of temperature—if sudden—may result in temporary illness, and that even when the new climate is more conducive to the well-being of the individual than the one to which he has been accustomed; so that any temporary inconvenience is due, not to inferiority of climate, but to the *changed conditions* to which the organism has first to adapt itself. Should the individual, after having lived for a prolonged period under such new conditions, return to his former abode he would have to reacclimatise himself.

All this is common knowledge. What I desire to prove, however, is that it is a "property" of the *substance itself* of which our bodies are built up, and not of the complex organism. It is *each individual cell* that possesses this *adaptability to conditions* and the *tendency*

to continue the same conditions, or the "habit" they have established. Thus the heart of an animal continues to throb after it has been removed from the body and its action is no longer required. And if artificial conditions could be contrived that would enable it to live apart from the body—analogous to those of a transferred leg, tail, or piece of skin—it would continue to throb and to pump, though no longer to any purpose.

This "law," true of every cell whether living a unicellular (or "nomadic") kind of existence, or whether forming part of the most complex organism, may be thus stated: *The organic cell has a tendency to persist in whatever condition it may happen to be, and to resist change.*

It has *a tendency to resist change,* but not the power to do so always successfully. Modified conditions would tend to modify the established habit, and the change, or the adaptation to the new conditions, would take place in proportion to the relative intensity of the

two contending forces: the tendency to *persist* and the new conditions that tend to modify the former "habit."

The more recent a "habit," the more readily is it modified, and *vice versa.* We might generalise this well-established fact into another "law," thus: The force of persistence is proportional to the time of its duration. As this applies to each individual cell, it, of course, applies to any aggregation of cells, or to any more or less complex organism.

This "persistence" is the most common manifestation of life and of living beings—by and by I hope to be able to show that it is the secret of life itself—and that may account for the fact that such little notice has been taken of it in the study of life. It manifests itself in various forms, and is spoken of as "habit," "instinct," "heredity," "predisposition," etc., but it has not hitherto been recognised as a distinct principle or *factor* in life, but rather as a *product* of it.

VI

By help of the principles of "adaptation to conditions" and "persistence of acquired habits" we can account for specialisation. Nor need this be done speculatively. As in the illustration given in my first paper of the manner in which the evolution of the oak from the acorn might be proved from experiments supplied by Nature, so might we trace the evolution of every organ, of every habit, of every faculty—even to the emotions and sentiments—and find suitable experiments supplied by Nature to illustrate each stage in the process, from the simple "nomadic" cell to the most complex organism, including man himself.

The limits of these pages, however, would not allow me to enter so fully into the evidence. A mere outline sketch is all that is permissible, and consequently I must leave it to the imagination of the reader to fill in the details.

He should not find it difficult to do so, however, if he has followed me so far attentively. The requisite knowledge is possessed by all of us; we need only draw on our experience of life. Great as is the mystery of it, life is the one thing about the manifestations of which we possess more actual experience than about anything else—naturally so. It is merely a matter of applying that knowledge intelligently and of drawing conclusions from it by help of "the laws of evidence" in order to see *life in the making.*

Let us start to observe, in imagination, one of those "nomad" cells, each of which lives independently and apart from the others; say, a yeast cell. And here I would remark that the term "cell," in the sense in which I shall use it, is hypothetical rather than real. A bacterium, or a particle of yeast, may seem a single cell to the eye only. I will not discuss whether it actually is or is not; I shall regard it as such, for it does not

affect my argument whether this view is literally correct or not. Such a yeast "cell," or a sugar-mite, can live and multiply in a saccharine solution containing the necessary constituents to build with. Incidentally or necessarily —we do not know which—this simple organism splits up the sugar into alcohol and carbon dioxide. It withdraws from the fluid in which it lives such material atoms as it builds with—carbon, hydrogen, nitrogen, etc.—and arranges these into combinations such as it consists of itself, and which we shall designate "plasm" —a name that will serve the purpose as well as any other. This substance, whatever its constitution, possesses the two properties mentioned—namely, adaptation to surrounding conditions, and retentiveness or "persistence." The plasm thus formed from its elements by the living cell could have no *prior* dispositions or habits, and therefore the conditions of its genesis would naturally be its own "conditions." It would, therefore,

at once possess all the dispositions of the parent cell.

This would explain why a sugar-mite (*saccharomycetes*, to give it its full-dress title) will produce a sugar-mite, whilst other microbes will create organisms like unto themselves out of the same raw material. The newly formed plasm could have no other dispositions than those of its genesis. The atoms, as they are assimilated, become at once part of the organism and partake of all its peculiarities. Here, then, we have "transmission of habits," or "heredity" in its simplest form.

Such low organisms multiply by fissure. They grow in size, but retain their shape. The new growth appears as an outgrowth, as a small wart or nodule, similar in shape to the parent cell; and when of a size approaching that of the latter, it separates and henceforth leads a separate existence.

With the law of "persistence" established in our mind, we may allow our-

selves to speculate also about the cause of this multiplication and reproduction. Size and shape may be one of the *acquired* habits and conditions of existence; the converting of heterogeneous atoms into cell-substance another. So that, the cell endeavouring to retain its size and shape, the newly formed plasm would appear as an appendage—an *outgrowth*; and when of a certain size, naturally possessing all the dispositions of the parent cell, it would separate to lead an existence like unto that of its parent.

Here let me digress for a moment in order to point out why, in my opinion, the chemist could not produce "life" or "living" matter. Chemistry has succeeded in producing synthetically many *products* of life, and may succeed eventually in producing others, including the proteid matter, or plasm, of which the bodies of organisms are built up. But that would be neither "life" nor "living" matter, since at the time of its formation

in the flask there could be no predispositions or inherited "habits" to respond to stimuli. It would be just matter like any other, with "chemical" and "physical" properties, but without "habit" or "psychic" life.

The objection might be raised that the first plasm produced by nature must at one time have been in a similar state. No doubt the objection is a valid one. Granted that the substance prepared by the chemist is capable of "differentiation," by which I mean the capacity of acquiring the power of responding to external stimuli and of retaining those powers even after the conditions have been modified, it would no longer be the *chemist* who endowed the substance with life; nor would the "life" be due to the chemistry of the substance. For, as I have pointed out already, it is the plasm itself that is the chemist, that makes the material combinations of which it is built up; and the first plasm, or protoplasm, would have to acquire some

"habit" before it could show manifestations of life.

To return to my subject, such a cell would reproduce itself of necessity, and the dispositions of the new cell would, also of necessity, be the same as that of the parent. But both old and new cells are capable of being modified by altered conditions, and *the new cell more readily than the old one.* The same is true of the several dispositions, functions, or habits of either; a more recently acquired "habit" being more easily modified than an old one, because its *persistence,* or power of resistance to change, is correspondingly lesser.

Let us assume that from some cause or other two such cells do not separate, but remain in contact—now a bi-cellular creature. That mode of existence may also become a "habit." In this way we may get by multiplication, without accompanying separation, an agglomeration of cells; something resembling a blackberry. We may further suppose

a cell in the centre of this mass so circumstanced that it is no longer in direct contact with the fluid in which these cells are floating and derive their nutriment from. In that case such a cell would have to draw its food from an adjoining cell, and this cell would therefore have to forage doubly—for itself as well as for the imprisoned cell. A new condition has thus arisen, which, like any other, will in time become an established condition of life: the one cell foraging for itself and its immediate neighbour, and the other being fed thus indirectly.

We may now rise a step higher in the scale, where we may see by actual observation what we have just now contemplated theoretically. There is a whole class of formless creatures called *stomata*, from the fact that they resemble a sack or stomach. In some cases they are rooted to a rock, and sometimes they float about, resembling a mass of jelly.

They seem to be able to push out

tentacles from any part of their body to apprehend food, and can absorb the latter anywhere—the whole mass being prehensile, mouth and stomach at the same time, and in every part of it. It is here where we observe the first signs of specialisation, and can trace the evolution of nerves, arteries, organs, and members. I do not deem it necessary to describe the process in detail. Adaptation and persistence are the creators of every organ, every member, every habit; and the physiological functions of the various organs, such as heart, lungs, kidneys, etc., are but the result of such specialisation.

The adventitiously pushed out tentacles become fixed organs of apprehension or locomotion; a buccal cavity becomes established as the regular channel of prey, a stomach is formed to receive the raw material and to transform it into available food, etc. A general division of labour takes place until the various groups of cells become organs, such as

we know them in the higher animals. As any such modifications are passed on to offspring, this building up and improving goes on through endless generations, and is still going on, from start to finish.

Some of the organs formed at the earlier periods of development have become superfluous through changed conditions, yet are passed on nevertheless; but not being used any more, they become atrophied and rudimentary. There are several such organs in the human body itself.

VII

Evolution from lower to higher forms of life proceeds in three distinct directions —form, function, and disposition. These are the subject matter of the three branches of biology known as morphology, physiology, and psychology.

Simultaneously and *pari passu* with specialisation proceeds the process of co-adaptation and the co-ordination of

organs. The cells in the complex body are no longer homogeneous, even if chemically they are identical. Each has a function of its own, and consequently a psychic life of its own, different from that of the rest.

Among the conditions of existence of each cell have to be reckoned the conditions of the other cells of the organism. The life-existences of the heart, the lungs, the kidneys, the stomach, etc., are all conditioned by and dependent on one another. The body may be likened to an empire consisting of several states, these again of smaller communities, in which to each citizen are assigned certain duties. It is this complexity which makes the phenomena of life so embarrassing. In its elements nothing could be simpler—and that, to my mind, is the most marvellous part of it.

Complex as man is, for instance, all that he is is due—primarily at least—to the psychic life of the individual cells of which his body is composed. Let me

emphasise this fact, since it strikes at the root of the problem. The psychic life of a complex organism is due not to the substance but to the psychic life of the cells which compose the organism; to their co-adaptation and co-operation.

The parts of the body could all continue to live if severed, provided we could supply artificially nutriment and such conditions as have become necessary to the existence of each. In the case of arms, legs, or skin, nutriment is the chief requirement, and could be supplied by grafting them on to another warm-blooded animal. There these parts would not only continue to feed and to live, but would complete growth if not fully developed, and, at the time of transplanting, possess all the powers of sensation and of responding to the accustomed stimuli as before. A hand thus transferred could grasp a stick, a pen, or a tool, and perform all the operations it had been trained to perform, provided that, through the severing of a muscle,

this had not been made physically impossible.

This is not deduction but observed fact. The palsied leg quoted on a previous page is an illustration in point. It could still perform every duty it had been trained to perform, and it was ready to perform it if called upon to do so by the accustomed stimuli. All that had been impaired was the "communication cord" whereby it was in correspondence with the other organs, and so it could no longer receive stimuli from that source.

It had been the general belief that the seat of sensation was in the brain, and many animals have been mutilated by the vivisector's knife to locate the different senses; but these experiments proved that the theory of seats of sensation in the brain was an erroneous one, and that the seat of sensation and the power to respond was in the cell itself, and that the brain was merely the "exchange" or "switch-room" that enabled

the different organs to communicate with each other and to co-operate.

After removal of the brain, the animal, if cared for, continued to live, and each individual member could perform all its functions, and did so perform them in response to accustomed stimuli. But all co-operation of the organs was at an end because the means of communication had been destroyed.

What Flourens, Hartwig, Magendie, Ferrier, and others have shown to be the truth in the case of animals, Darwin has proved to apply also to plants; whilst any number of pathological cases could be cited which establish that the same conclusions apply to man.

These conclusions are:—

1. That the life, physiological or psychic, is in the individual cell.

2. That this "life" consists in performing physiological functions (well characterised and distinguishable from what are called "chemical" or "physical" reactions, though not easily definable in

words) and making definite responses to stimuli.

3. That such physiological functions or responses to stimuli are acquired, may be modified, intensified, weakened, or entirely lost without any apparent chemical changes in the cell substance in connection with which these manifestations are observed.

4. That the cell itself makes the chemical compounds with which it builds, and impresses on the newly formed substance all its own dispositions and characteristics.

5. The organisation of the complex beings, as well as the chemical composition of the matter of which such beings are built up, is all the work of the cell itself, but does not constitute the life of the cell. In other words, the chemical compounds and the organisation of the being are both products of life and not the cause of it.

We thus have reduced the complex problem to its elemental constituents,

the functions of the cell. Given a single living cell in a medium where it can exist, and by means of the observed two characteristics of adaptation and persistence we can follow its course through all its stages of development to the most complex expressions of life—just as by means of the principles of lever and inclined plane we may explain the most complex mechanical contrivance.

We may account for specialisation, co-adaptation, co-ordination, and co-operation. Propagation even—so marvellous in the complex organism—when studied in its simplest manifestations, the fissure of the cell, seems almost a physiological necessity when viewed in the light of persistence. Once we can account for these, the rest may be accounted for by the now established principles of evolution.

We can thus trace the "mechanism of life"—if the phrase is admissible—from cell to oak or cell to man. Can this

throw any light on the origin of life? Let us see.

VIII

So far we have been on solid ground. I have advanced nothing but what is amply warranted by well - ascertained facts and is demonstrable from observation or by experiment. The law of persistence which I introduce is but a generalisation of well-known facts, a convenient expression whereby to refer to certain phenomena.

The living cell does adapt itself to conditions, and beyond doubt retains the acquired habit even after the conditions have been changed; though subject to subsequent modifications in consequence of changed conditions. This is all I mean by "persistence." Every physiological function, every vital act or manifestation may, therefore, be said to be an acquired habit transmitted from parent to offspring—I am thinking of the cell and not of the complex organism

—modified and amplified during generations.

A substance without any such established habits would be lifeless, whatever its composition, organisation, or form. Therefore, a substance generated in the chemist's flask or crucible would, of necessity, be lifeless, even though chemically as identical with the natural proteid substance as is the cell-substance of the germ of a bird with that of a mammal; or as is the "chromatin," "cytoplasm"—or whatever you may prefer to call it—of, say, a mustard seed with that of an acorn.

But, it may be asked, Could not the chemist produce a substance capable of acquiring such habits? I see no reason to deny the possibility, nor do I see the profitableness of arguing the point one way or the other. It would no more be life that he has created than the artificial production of iron would be a mechanism.

The question before us is how the first cell originated. It is at this point where

the facts fail us and speculation must begin. But though the facts themselves do not allow us to proceed any further, they enable us to draw conclusions which seem reasonable and probable. That I shall now proceed to do; not, however, without remembering that they are inferences only and in need of subsequent verification.

Adaptation to conditions being the means of acquiring new habits or modifying old ones, it seems but reasonable to suppose that the same agency was the origin of the first habit. On this supposition let us allow the imagination to step in and see what it can make of this hypothesis.

A certain substance, which in these pages I designated by the name of "plasm," possesses the particular characteristic of sensitiveness to external influences. Darwin had observed how the fluid contents of the cells of a leaf respond to the slightest changes of conditions, causing aggregations of the sap

in the cells—now in one direction, now in another — a change of colour, or some other modification. Let us suppose a mass of such substance possessing this sensitiveness, but as yet unacted upon.

It is difficult to conceive of such a substance in a state of neutrality or inertness; for at the moment of its genesis it naturally would be predisposed towards its conditions whatever these might happen to be; but for the purpose of this study we may ignore this difficulty. Indeed, we might assume for the purpose of this argument that the chemist has succeeded in synthetising such a substance and in being able to preserve it against decomposition.

If we could keep the conditions constant, the jelly—as I imagine it to be —would remain inert. If the conditions changed, but irregularly, no two changes being alike, then, though the jelly responded to every change of conditions, no definite disposition could be established. But supposing a certain agency were to

act intermittently and repeatedly, then, as there would be a repetition of the same response whenever the same disturbance occurred, the plastic property of the jelly would assert itself and the first signs of physiological action would be called into being.

The mass would at once be differentiated, even though to the eye no change may be observable; for the particles next to the glass—in imagination the jelly is still in the chemist's flask before me — would be under different conditions than the particle next to it away from the glass. In fact I cannot imagine any two particles in that flask to be under exactly the same conditions; yet each would be affected—directly or indirectly—by any external change. For if particle A changes in response to some external agency, the adjacent particle is no longer under the same conditions and would change likewise; and so on throughout the whole mass. The same change in A would

always evoke the corresponding changes in B, C, D, . . . etc.

But in doing so this altered state of B, C, D, . . . etc., would also alter the condition of A itself, until throughout the mass the particles have adapted themselves to each other, conditions *a*, *b*, *c*, . . . etc., in A corresponding to conditions *a*, *b*, *c*, . . . etc., in the other particles, which we may now consider as "cells." Whenever the agency which produced the change *a* in A is active, all the other cells would assume the corresponding state, the changed condition of the one being the stimulus for the adjacent cell. The oftener these changes occur, the more readily will follow the response, until a reciprocal habit has been established.

Further than this it is not necessary to go for the present purpose. As differentiation under the influence of altered conditions is possible, the origin or first habit may be conceived as being due to the same cause. However simple

or rudimentary this first adaptation to conditions may be, it is a beginning; so that the plasm given, the rest could all be explained mechanically.

All! except that subtle elusive "something" in virtue of which the plasm acquires, retains, and transmits its habits.

We may thus trace life back to its beginnings, and may hope to solve in time all its processes—including that of thinking — and even succeed in compounding a substance capable of receiving or acquiring those peculiarities we call "life." And then

> "Hat er die Theile in seiner Hand,
> Fehlt leider! nur das geistige Band." (Goethe.)[1]

It would not be life that the chemist has produced, though capable of receiving it; just as iron would not be a machine though it might serve as the material for one. The "protoplasm," "cytoplasm," "chromatin" — call the

[1] "The parts are all safe in his hand,
Except, alas! the soul that binds them."

material substance what you please—would be lifeless at first and lifeless at last, even after having possessed life, having been organised and built up by the living cell into a most wonderful mechanism. "Dust thou art, and unto dust shalt thou return." That is all that can be said of the material body built by the living cell; it would be foolish to suppose that the chemist could do better. He might make the substance, he might build up the body even in all its wonderful details, but he could not make life itself.

Then what is it, you ask, that gives life to the material substance? That teaches the "cell" to take form; to acquire habits and get more and more proficient in its responses as it gains experience; to learn discipline; to take atoms of carbon, hydrogen, nitrogen, oxygen, etc., from most heterogeneous substances, arrange them into new and most diverse combinations that excite the envy of the chemist; to build with

these self-made molecules structures which shame our sculptors and architects; to blend colours into designs the wonder and admiration of our artists; and to contrive mechanisms compared with which the most elaborate creations of man are but clumsy devices?

With head bent and awestruck humility I answer, I do not know. I may explain the mechanism of life; I do not know what *it* is that makes *it*.

Materialist and mystic are on either side of me, the one calling out jubilantly, "It is matter and nothing else"; and the other droning, "It is a spirit like myself, only bigger, more powerful and cleverer." I may not heed either; for scanty as is the information afforded by the facts, it is sufficient to contradict both materialist and mystic.

As I contemplate the problem before me, I am spellbound by the display of —What? I have not even a name for it. I have called the mysterious power "persistence" or "habit." Men more

learned in Greek and Latin than myself will be able to suggest some more pretentious, more classical-sounding, perhaps even a more appropriate name. But it will not help us to pierce the secret. For the nearer we get to it the greater —and not lesser—becomes the marvel and the mystery of it. For what is this "persistence" by means of which I endeavoured to account for the mechanism of life? In ultimate analysis it resolves itself into time or duration—something I cannot even grasp the meaning of.

Here I stand on the brink of ascertained facts looking out into the vast beyond. Far off on the mental horizon, in the misty realms of the imagination, I can dimly see an ethereal loom, worked by invisible powers, weaving something out of nothing—or what to me seems nothing. I am tempted to get nearer to it, but cannot do so without loosing my foothold on the facts, to which I needs must cling. So soon as I lose touch of these I am tossed about in a sea of dark-

ness and uncertainty. And so I continue gazing at the far-off vision without hope of ever reaching it, for between it and my mortal self there yawns the chasm of—eternity.

THE END

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